1 **TITLE**

2 Rock Saw

3

4 **CROSS REFERENCE APPLICATIONS**

5 This application is a non-provisional application

6 claiming the benefits of provisional application no.

7 60/399,340 filed 7/29/2002

8

9 **FIELD OF INVENTION**

10 The present invention relates to automatic rock saws.

11 More particularly, the present invention is an automatic

12 rock saw with a conveyer that is controlled such that the

13 speed of the rock being conveyed to the blade to be cut is

14 controlled according to the workload of the saw blade. The

15 present invention also discloses a rock saw with a

16 horizontal and vertical blade, so that corners can be cut in

17 a rock in one pass.

18

19 **BACKGROUND OF THE INVENTION**

20 Saws that cut rock, brick and similar materials are

21 well known in the art. Using a conveyor belt to carry the

22 material to the blade is also well known in the art. One of

23 the common problems with conveyor belt systems is that the

24 conveyor carries the material to the blade at a given speed.

25 With rock in particular, the material can have irregular

26 shapes and varying degrees of hardness and/or thickness,

27 resulting in a wide variation in the difficulty of cutting a

28 given piece. It is well known in the art to control the

29 pressure of the saw blade, so that the saw blade does not

30 change speed as the blade encounters harder and softer

31 substances, thereby increasing blade efficiencies and

32 extending equipment/tooling life.

1   The problem presented by the prior art is that the
2 conveyor belt continued to present the material at a given
3 rate of speed, regardless of how hard the saw motor has to
4 work. This increases the wear on the saw and can cause
5 premature blade segment wear and even blade segment
6 separation from the blade core, which is a distinct hazard.
7 Furthermore, as the material being cut is forced upon a
8 blade already working at maximum capacity, drive train
9 components, and eventually the prime mover, may prematurely
10 fail.
11   Another problem in rock saws is that there is a demand
12 for "corner pieces" of facing rock to use for building
13 faces. The corner pieces need to have an interior corner
14 cut into the rock so that the rock can be placed on the
15 corner of the building. At the present time these pieces
16 need to be cut by hand using freestanding rock saws. This
17 is time consuming, costly and can result in large amounts of
18 spoilage while forcing the saw operator to work in close
19 proximity to a rotating, exposed saw blade.
20   The present invention solves these problems by using a
21 saw motor load sensor to control the speed of the conveyors
22 bringing the rock to the saw blade. As the saw motor works
23 harder to cut a given rock, the controller automatically
24 slows the conveyor belts, reducing the load on the saw
25 blade. If the saw blade is easily cutting a given rock and
26 not working at optimum speed, the conveyors will be sped up,
27 increasing production.
28   Also provided in an alternate embodiment is a
29 horizontal blade that can be moved into place to cut the
30 "bottom" of a corner piece, then the standard, vertical
31 blade cuts the other side of the corner.
32   Common in all manual rock cutting operations is the
33 need to produce a clean finished product. Manual sawing of

1   stone produces fines, a gritty, slurry like material of rock

2   dust and water. As the water dries from the finished

3   product, a thin film of rock dust remains on the product

4   changing the color of the slab. In manual operations, this

5   slurry like material is often sprayed onto the saw operator

6   becomes airborne as a mist. Without proper respirators this

7   mist can expose the operator to silicosis. A water spray

8   that both cleans the finished product and causes the mist to

9   be directed away from the operators can be incorporated in

10 all embodiments, potentially reducing the risk of silicosis.

11

12   **SUMMARY OF THE INVENTION**

13   The primary aspect of the present invention is to

14 provide a rock saw that has variable speed conveyor belts

15 which are controlled by the work load on the saw motors.

16   Another aspect of the present invention is to provide a

17 rock saw that can automatically cut corner pieces.

18   Other aspects of this invention will appear from the

19 following description and appended claims, reference being

20 made to the accompanying drawings forming a part of this

21 specification wherein like reference characters designate

22 corresponding parts in the several views.

23

24   **BRIEF DESCRIPTION OF THE DRAWINGS**

25 FIG. 1 is a front plan view of the present invention with

26   the safety covers removed.

27 FIG. 2 is a top plan view of the present invention as shown

28   in FIG. 1

29 FIG. 3 is a top view of rock being cut in the present

30   invention.

31 FIG. 4 is a side plan view of a rock being cut in the

32   present invention.

1   FIG. 5 is a plan view of the control box of the present
2   invention.
3   FIGS. 6a and 6b are a flowchart showing one possible control
4   logic of the present invention.
5   FIGS. 6c and 6d are a flowchart showing the control logic of
6   an alternate embodiment of the present invention.
7   FIGS. 6e and 6f are a flowcharting showing the control logic
8   of an alternate embodiment of the present invention.
9   FIG. 7 is a front plan view of the present invention with
10   the safety covers in place.
11   FIG. 8 is a front plan view of an alternate embodiment of
12   the present invention with a horizontal blade.
13   FIG. 9 is a top plan view of the alternate embodiment as
14   shown in FIG. 8.
15   FIG. 10 is a side plan view of a corner piece being cut in
16   the alternate embodiment shown in FIG. 8.
17   FIG. 11 is a front plan view of a control panel of the
18   present invention.
19   FIG. 12 is a front plan view of an alternate embodiment of
20   the present invention.
21   FIG. 13 is a side plan view of FIG. 12.
22   FIG. 14 is a top plan view of FIG. 12.
23   FIG. 15 is a graph showing the relationship of saw motor
24   current vs. conveyor speed for the embodiment of FIGS.
25   6e and 6f.
26   Before explaining the disclosed embodiment of the
27   present invention in detail, it is to be understood that the
28   invention is not limited in its application to the details
29   of the particular arrangement shown, since the invention is
30   capable of other embodiments. Also, the terminology used
31   herein is for the purpose of description and not of
32   limitation.
33

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DETAILED DESCRIPTION OF THE DRAWINGS

1
2   The present invention can be used to cut rock,
3   concrete, block, clay brick or any similar hard material.
4   For simplicity, only the cutting of rock will be
5   specifically mentioned, but it is understood that the
6   cutting of all of the other materials is included within the
7   scope of this invention.
8   Referring first to FIGS. 1 and 2, the rock saw 1 has a
9   frame 2 and a vertical blade 4. The vertical blade 4 is
10 driven by blade motor 5 that is connected to the vertical
11 blade 4. This connection can be done in a variety of
12 manners well known in the art. The rock saw 1 has a main
13 conveyor 3 and a vertical conveyor 6, which are both driven
14 by conveyor motor 7, again in a known manner. The main
15 conveyor 3 has rollers 8,9 and a conveyor belt 10. The
16 conveyor belt 10 is made of a durable material to hold the
17 heavy rocks and so that any accidental contact of the
18 vertical blade 4 with the conveyor belt 10 will not cut the
19 conveyor belt 10. The main conveyor 3 can either be fixed
20 in place or can be adapted (not shown) to move vertically in
21 relation to the vertical blade 4. The embodiment shown in
22 FIGS. 1, 2 and 3 allows for main conveyor 3 to be lifted by
23 means of plastic shims (not shown) along the entire length
24 of the work surface. This allows for blade wear, maximizing
25 blade segment usage.
26   The vertical conveyor 6 is located behind the vertical
27 blade 4 and is spaced a given distance D1 from the vertical
28 blade 4. D1 will be the thickness of the rock slice B that
29 is cut by the rock saw, as shown in FIG. 3. The vertical
30 conveyor 6 is mounted on frame 11, which is attached to
31 frame 2. The vertical conveyor 6 can be moved closer to or
32 away from the vertical blade 4 at adjustment points 12, 13

1 as shown in FIGS. 2 and 3. This allows the vertical

2 conveyor 6 to be moved towards or away from vertical blade

3 4, changing D1 and the thickness of the rock slice B. In

4 the preferred embodiment the range of D1 is up to 3 ½

5 inches. The adjustment points 12, 13 are threaded screws

6 (not shown) to allow the vertical conveyor belt 6.1 to be

7 infinitely adjusted with the range of movement. However,

8 other known adjustment mechanisms could be used instead.

9   As shown in FIGS. 2 and 3, a holding mechanism 14 is

10 provided to hold the rock A against the vertical conveyor 6

11 until the rock A is engaged with the vertical blade 4, as

12 shown in FIG. 3. The holding mechanism 14 consists of one

13 or more spring loaded holding arms. The holding arms move

14 in the direction of arrows X as the rock A moves along the

15 conveyors. The holding arms can take a variety of forms

16 depending on the material to be cut. In the disclosed

17 embodiment there is a rocking panel arm 15 and a roller arm

18 16.   The rocking panel arm 15 has a slightly curved holding

19 panel 15.1, which is pivotally attached to the main arm 15.2

20 at pivot 15.3. The holding panel 15.1 is biased towards a

21 parallel alignment with the vertical conveyor 6 with spring

22 arm 15.4. The roller arm 16 has a roller 16.1 rotatably

23 mounted on main arm 16.2.

24   Both the rocking panel arm 15 and the roller arm 16 are

25 pivotally attached to the frame 2 and are sprung towards the

26 vertical conveyor 6 with springs (Not shown) in boxes 14.1.

27   As best shown in FIGS. 3 and 4, in operation rocks A,

28 or other material to be cut, are loaded on front end 17 of

29 the main conveyor 3. The conveyor 3 carries the rocks A

30 toward the vertical blade 4, as shown by arrow Y. The rocks

31 A move along conveyor 3 and are carried up against holding

32 mechanism 14. Holding mechanism 14 presses the rock A

33 against vertical conveyor belt 6.1, which travels at the

1   same speed as the main conveyor 3. Rock A is then carried
2   up to leading edge 4.1 of vertical saw 4. Depending on the
3   hardness of the rock A, the speed of the conveyors 3 and 6
4   maybe varied as described below to allow for maximum
5   efficiency of rock cutting. Once the rock A has been cut
6   slab B with a thickness of D1 is created. Rock A can either
7   be re-cut for more slabs or disposed of, depending on the
8   application.
9   Blade 4 is water-cooled and cleaned with jets with
10 water in a known manner and is therefore not shown. The
11 water drains into trough 18 and is drained from there by
12 drain 19. In addition, final jets 25, shown in FIG. 1, of
13 water are used to clean the cut slab B of cutting debris and
14 to reduce the amount of rock dust that is put into the air.
15 The plumbing of the jets 25 is well known and therefore not
16 shown. This eliminates a final cleaning step necessary in
17 manual operations. The reduction of the amount of dust put
18 into the local atmosphere may also reduce the health risk to
19 the operators of the machinery by possibly reducing the risk
20 of silicosis.
21   FIG. 7 shows the rock saw 1 with a complete set of
22 safety covers 20, 21. Although the safety covers 20, 21 are
23 not necessary for the operation of the invention, they are
24 advantageous to the safe operation of the machine and may be
25 required by work place safety rules. In addition, in
26 combination with the water jets and the safety cover may
27 reduce the amount of dust released into the atmosphere by
28 the operation of the rock saw 1 and thereby possibly reduce
29 the risk of silicosis in operators.
30   An alternate embodiment of the present invention is
31 shown in FIGS. 8, 9 and 10. A rock saw 100 has a frame 200,
32 a vertical blade 400. The vertical blade 400 is driven by

vertical blade motor 500 which is connected to the vertical
blade 4 in a manner well known in the art.

The rock saw 100 has a main conveyor 300 and a vertical
conveyor 600, which are both driven by conveyor motor 700,
again in a known manner.

The main conveyor 300 has rollers 800,900 and a
conveyor belt 1000. The conveyor belt 1000 is made of a
durable material to hold the heavy rocks and so that any
accidental contact of the vertical blade 400 not cut the
conveyor belt 1000. The main conveyor 300 can either be
fixed in place or can be adapted (not shown) to move
vertically in relation to the vertical blade 400. Conveyor
300 can be moved in the vertical positions relative to blade
400 at the same time by incorporating a series of
interconnected jackscrews mounted on frame 200 or other
known adjustable mechanisms. The adjustable mechanism must
be capable of being exactly adjusted to a given location and
the adjustment mechanism must be able to withstand the
vibrations of the operation of the saw 100 without moving.

The vertical conveyor 600 is located behind the
vertical blade 400 and is spaced a given distance D1 from
the vertical blade 400. D1 will be the thickness of the
rock slice C that is cut by the rock saw. The vertical
conveyor 600 is mounted on frame 1100. The vertical conveyor
6 can be moved closer to or away from the vertical blade 4
at adjustment points 120, 130 as shown in FIGS. 9 and 10.
This allows the vertical conveyor 600 to be moved towards or
away from vertical blade 400, changing D1 and the thickness
of the rock slice B. In the preferred embodiment the range
of D1 is up to 3 ½ inches. The adjustment points 120, 130
are threaded screws (not shown) to allow the vertical
conveyor belt 601 to be infinitely adjusted with the range

1 of movement. However, other known adjustment mechanisms
2 could be used instead.
3   As shown in FIG. 9, a holding mechanism 1400 is
4 provided to hold the rock A against the vertical conveyor
5 600 until the rock A is engaged with the vertical blade 400,
6 as shown in FIG. 9. The holding mechanism 1400 is basically
7 the same mechanism as holding mechanism 14 described above.
8 The holding arms need to be placed such that they do not
9 interfere with horizontal blade mechanism 2000. The
10 horizontal blade mechanism 2000 has a horizontal blade 2001
11 which is substantially parallel to main conveyor 300 and
12 substantially perpendicular to vertical blade 400 as shown
13 in FIG. 10.
14   The horizontal blade mechanism 2000 in the preferred
15 embodiment is pivotally mounted to frame 200 at point 201
16 via mounting arm (not shown). The horizontal blade 2001 is
17 powered by horizontal blade motor 2002 and connected to the
18 blade 2001 in a known manner. In operation to cut a corner
19 piece both blades 400 and 2001 will be in operation
20 simultaneously as shown in FIG. 10. The need for the
21 holding arms is lessened in the operation of corner cutting
22 since the horizontal blade 2001 will help hold the rock A
23 against the vertical blade 400, therefore one of the holding
24 arms may be removed for corner cutting operations.
25   An additional alternate embodiment is shown in FIGS.
26 12, 13 and 14, the rock saw 1200 has a frame 1202, and a
27 vertical blade 1204. The vertical blade 1024 is driven by
28 blade motor 1205 that is connected to the vertical blade
29 1204. This connection can be done in a variety of manners
30 well known in the art. The rock saw 1200 has a main conveyor
31 1203 and a vertical conveyor 1206, which are both driven by
32 conveyor motor 1207, again in a known manner. The main
33 conveyor 1203 has rollers 1208, 1209 and 1209a and a

conveyor belt 1210. The offset rollers 1209 and 1209a help
prevent slack in the conveyor belt 1210 when the direction
of operation of the belt 1210 is reversed.

The conveyor belt 1210 is formed of durable material to
hold the heavy rocks and is divided into two pieces 1210a
and 1210b, as best seen in FIG. 14. Section 1210a is on the
outside of the vertical blade 1204 and section 1210b is
between the vertical blade 1204 and the vertical conveyor
1206. There is a gap 1210c between the two sections 1210a
and 1210b. As shown in FIG. 13 the vertical blade 1204 can
extend down into the gap 1210c. This prevents the vertical
blade from cutting the main conveyor belt during operations.
This also allows for blade wear without having to adjust the
position of the main conveyor 1203. A new vertical blade
1204 can be set so that it extends well into gap 1210c.
Even after substantial blade wear has occurred, the blade
1204 will still cut all the way through the rock A. This
sectional arrangement of conveyor 1206 also reduces blade
wear, as the blade 1204 no longer comes into contact with
conveyor belt 1210.

If desired, the gap 1210c can be covered with metal
plates on those areas in front of and after the blade 1210
to reduce the risk of debris falling between the sections
1210a and 1210b. The two sections are driven by cam 1218,
shown in FIG. 16.

The vertical conveyor 1206 is located behind the
vertical blade 1204 and is spaced a given distance D1 from
the vertical blade 1204. D1 will be the thickness of the
rock slice B that is cut by the rock saw, as shown in FIG.
14. The vertical conveyor 1206 is mounted on frame 1211,
which is attached to frame 1202. The vertical conveyor 1206
can be moved closer to or away from the vertical blade 1204
at adjustment points 1212, 1213 as shown in FIG. 14. This

1 allows the vertical conveyor 1206 to be moved towards or
2 away from vertical blade 1204, changing D1 and the thickness
3 of the rock slice B. In the preferred embodiment the range
4 of D1 is up to 3 ½ inches. The adjustment points 1212, 1213
5 are threaded screws (not shown) to allow the vertical
6 conveyor belt 1206.1 to be infinitely adjusted with the
7 range of movement. However, other known adjustment
8 mechanisms could be used instead.
9   As shown in FIGS. 12, 13, and 14, a holding mechanism
10 1214 is provided to hold the rock A against the vertical
11 conveyor 1206 until the rock A is engaged with the vertical
12 blade 1204, as described above. The holding mechanism 1214
13 consists of one or more spring loaded holding arms. The
14 holding arms move in the direction of arrows X in FIG. 14 as
15 the rock A moves along the conveyors. In the embodiment
16 shown in FIGS. 12, 13 and 14 there are two full sized arms
17 1215 and a short arm 1216.   All three arms are pivotally
18 mounted base 1220 which are attached to frame 1219. The
19 arms 1215 and 1216 are spring biased toward the vertical
20 conveyor to hold the rock A against the vertical conveyor
21 1206.
22   The roller arms 1215 and 1216 have rollers 1221
23 rotatably mounted on arms 1215 and 1216. Arms 1215 have
24 four rollers each. Arm 1216 only has rollers 1221 on the
25 bottom side, as best shown in FIG. 12. This allows arm 1216
26 to be placed closer to the vertical blade 1204, under the
27 curve of the blade 1204. This helps prevent the rock A from
28 being deflected outward by the blade 1204 and provides for a
29 more even cut.
30   Blade 1204 is water-cooled and cleaned with jets with
31 water in a known manner and is therefore not shown. The
32 water drains into trough 18 and is drained from there. In
33 addition, final jets 1225, shown in FIG. 12, of water are

used to clean the cut slab B of cutting debris and to reduce
the amount of rock dust that is put into the air. The
plumbing of jets 1225 is well known in the art, and
therefore not shown. This eliminates a final cleaning step
necessary in manual operations. The reduction of the amount
of dust put into the local atmosphere may also reduce the
health risk to the operators of the machinery by possibly
reducing the risk of silicosis.

As mentioned above the speed of the conveyors in all
embodiments is controlled automatically by the load on the
saw motor 5, 500 and 1205. The flowcharts 600a of FIGS. 6a-
6b, 600b of FIGS. 6b-6d, and 600c of FIGS. 6e and 6f show
different embodiments control logic of the present
invention. The present invention can have provision for
both manual operations and automatic operations. The
electronics inside the control box 555 are shown in FIG. 5.
For clarity, all of the wiring connecting the various
components has been omitted.

The wiring is connected to.wires Z, which connect the
control box to the relevant parts of the present invention.
It is to be understood that the specific electronics
disclosed were selected for the power of the present
embodiment and are discussed for illustration only. No
limitation should be inferred. If a larger or smaller saw
were needed then different components may well be required.
The layout of the control box 555 disclosed is for
illustration only and no limitation should be inferred.
There are many potential ways to layout the components of
the control box 555 depending on the particular application.
Various considerations could affect the layout of the
control box 555, including, but not limited to, space,
options available to operators vs. supervisors, cost of

1   components, cultural layout preferences and other known

2   human factor considerations.

3   As shown in FIG. 5, the control box 555 has a main

4   circuit breaker and a fuse 501 for the programmable logic

5   controller (PLC). In the disclosed embodiment a 20 amp

6   circuit breaker and a 3 amp fuse respectively are used. The

7   selection of circuit breakers and fuses depend the power of

8   the machinery to be run and are well know in the art. Next

9   to the fuse 501 is the saw control relay 502, which is next

10   to the power supply 503 for the saw motor load sensor 504.

11   A 24 volt DC power supply is used in the current embodiment.

12   The micro PLC 506 has 120 VAC output card and an analog

13   input and output cards. The master control relay 507 is

14   provided for all control power in the present invention.

15   The safety cover 21 can be locked closed by an

16   electromagnetic locking switch that is controlled by a power

17   supply 508, and a lock release solenoid control relay 509.

18   If the machine senses that the blade or blades are moving,

19   it will not allow the lock to be opened. Only once the

20   blades are no longer moving can the safety covers be opened.

21   In addition, if the safety covers are not closed, the

22   machine will not start the saw motors, as shown in box 607

23   of FIGS. 6a and 6c and box 603 of FIG. 6e in the automatic

24   mode.

25   The variable frequency drive (VFD) 513 is controlled by

26   control relays 510, including a start forward control, a

27   selector control relay, a manual feed select control relay,

28   a run enable control relay and a jog reverse select control

29   relay. The water solenoid can be controlled by control

30   relay 511. The saw motor is started with starter 512, which

31   has an overload relay to sense if the saw motor is

32   overloaded as shown by line 608 in FIGS. 6a, 6b 6c, 6d and

33   6f. If the motor is overloaded, the motor will be shut down

13

1 or not allowed to start. This is sensed by the saw motor

2 load sensor 504, which also controls the speed of the

3 conveyors through the variable speed drive 513.

4   The saw motor 5, 500 and 1205, the variable frequency

5 drive 513 and the control power transformer (not shown) are

6 provided with separate fuses, 514, 515, and 516

7 respectively.

8   One possible control panel C is shown in FIG. 11. The

9 saw 1 has an emergency stop button 1101, indicated by box

10 606 FIGS. 6a, 6c and 6e on flowchart 600a, 600b and 600c.

11 If this button is depressed, then all operations are halted

12 and cannot be re-started until the button is reset. The

13 power on button 1102 powers the machine and depressing this

14 button 1102 starts the process of operating the present

15 invention, as shown by box 602 FIGS. 6a, 6c and 6e. If the

16 power is on light 1103 is lit, indicating the operation

17 condition. The saw can have two modes of operation, an

18 automatic mode and a manual mode. The mode is selected by

19 setting the selector switch 1104 to either manual box 609 or

20 automatic setting box 610 in all flowcharts 600.

21   The manual operations are shown in box 601 of FIGS. 6a,

22 6c and 6e. The saw motor 5, 500, 1205 must be turned on by

23 pressing saw start button 1106 as indicated by box 612 FIGS.

24 6a and 6c. Next, as indicated by box 618, the conveyor

25 forward start button 1109 is pushed, starting the conveyors

26 moving toward the blade. The conveyors are stopped by

27 pressing conveyor forward stop button 1110.

28   In the manual mode the speed of the conveyors in either

29 forward or reverse is not controlled by the load on the saw

30 motor, the conveyors are run at one continuous speed.

31   The conveyors can be run in reverse in the manual mode,

32 this is provided to allow the operator to clear a jam or any

33 debris out of the path of the blade. The conveyors can be

set to run continuously in reverse by switching conveyor
direction switch 1107 to reverse if one is provided. The
conveyors can also be temporarily run in reverse by holding
down conveyor jog button 1110, in which case the conveyors
will run in reverse as long as the button 1110 is held down,
as indicated on flowcharts 600 by box 613.

In some operation conditions, it may be desirable to
not allow manual forward operation, but only reverse
operation to clear jams. In some cases the operators may
try to clear to a jam by manually running the saw forward,
instead of reversing the saw to pull the blockage. This is
particularly likely if the jam occurs near the end of a
cutting operation for a particular rock A. Running the saw
forward to try clear a jam can cause significant motor or
blade wear. Therefore, in some operating conditions it may
be desirable to either not have a forward manual mode, shown
in FIG. 6e, or to require a supervisor override to allow it
(not shown). This supervisor override could be as simple as
placing a locked box over the controls, or could be a
computer override requiring a password which could be
entered either at the saw or remotely.

The automatic run is started by pressing the power on
button 1101, as indicated at box 602 and ensuring that
selector switch 1104 is set to automatic as indicated in box
610. Next the automatic start button 1111 is pushed, box
618 and the machine checks the status of the necessary
machinery as shown in box 603. The machine, as shown in box
607 in FIGS. 6a and 6c and box 603 in FIG. 6e, checks if
safety covers are closed in those embodiments with automatic
safety covers. The conveyor motor 7, 700, 1207 is
controlled by a variable frequency drive (VFD) 513, which
allows the speed of the conveyors to be varied according to
the information about the load on the saw motor as shown in

box 604a, 604b and 604c. If the motor load on the saw is
above the safety range for the particular motor the saw and
the conveyors will automatically be shut down as shown in
boxes 605 FIG. 6b, 6d and 6f.

The automatic start button 1111 being pressed starts
the saw motor timer, box 620 FIGS. 6b, 6d and 6f. The saw
motor starts, moving the blade, and the load on the saw
motor is determined, box 621 in all flowcharts 600. The saw
motor timer box 620 controls the start of the VFD of the
conveyors. This allows the saw to reach full speed before
the conveyors start moving material to be cut to the blade.

In the embodiment shown in FIGS. 6e-f, an additional
control option is shown. The control panel can have a rock
hardness selector box 640, FIG. 6f. This allows the
operator to select for the hardness of the rock (or other
substance) to be cut. Two settings are shown, hard and
soft. It would be possible to have more settings if
desired. The selection of the conveyor speeds and motor
loads for different types of substances could be determined
by experimentation on the material to be cut and knowledge
of one skilled in the art of industrial saws.

The conveyors are then moved forward at a rate of speed
inversely proportional to the load on the saw motor, box
604all, controlled by the conveyor variable speed drive 513
. A 50 Amp maximum current sensor 504 determines the saw
motor load and sends it to a 4-20 milliAmp current loop
output device which sends the saw motor load current to the
PLC analog input. A PLC analog output card, 4-20 milliAmp
current loop to the variable frequency drive 513 is the
current loop speed control input.

There is a range of operational conditions set for the
saw motor and the conveyors, boxes 604a, 604b and 604c,
which will be determined by the exact equipment used and the

16

1   material to be cut by the saw. Normally, these operational

2   conditions will be set into the machine and are not easily

3   variable. However, if desired, a programmable capability

4   could be built into the present invention to allow the

5   operator to set the operating conditions. This might be

6   particularly advantageous in a large embodiment of the

7   present invention that might be cutting a wide variety of

8   materials and a wide range of sizes and thicknesses of

9   material.

10   The speed of the conveyor is controlled in the

11   preferred embodiment on a mathematical curve relating to the

12   motor load, as shown in box 628 in FIGS. 6a and 6c. The

13   algorithm of the curve is as follows:

14   The PLC program uses a "Scale" instruction to produce a

15   certain output to the VFD speed control determined by the

16   saw motor load. The Rate is -15022 and the offset is 25450,

17   which is the slope of the saw motor load vs. the VFD speed.

18   The -15022 (Rate) is the result of the range of the input

19   divided by the range of the output (11750-5020)/(9120-13600)

20   = 6730/-4480 =-1.5022 and is multiplied by 1000. These

21   values are in engineering units, and represent the actual

22   milliAmp input and output (times 1000). The 11750 represents

23   the maximum current to send to the VFD for the desired

24   maximum speed set point of 30 hertz. The 5020 is the minimum

25   current to send to the VFD for the desired minimum (except

26   for 0) speed of 4 hertz. The 9120 represents the minimum saw

27   motor load current of 16 amps at which it is desirable to

28   start decreasing the speed of the conveyor. The 13600 is

29   the maximum saw motor load current of 30 amps at which the

30   conveyor feed reduced to a minimum until the load decreases

31   again. The negative Rate means that as one parameter goes

32   up, the controlled parameter goes down, an inverse

33   relationship.

17

1   The 25450 (Offset) is the scaled minimum (minimum speed
2 current output) - input minimum (minimum saw load current)
3 x slope (Rate figured above) as shown in box 628.
4   Box 604c of FIGS. 6e and 6f shows the details of the
5 control logic in an embodiment with a rock hardness selector
6 640. If the hardness is set to soft, line 641, the
7 conveyors will move faster in relation to the motor load.
8 If the hardness is set to hard, line 642, the conveyors will
9 move slower in relation to the motor load.
10   When the hardness is set to soft line 641 if the saw
11 motor load sensed is greater than or equal to 16 Amps, then
12 the VDF is set to 30 Hz box 643. As shown in box 644, if
13 the saw motor load sensed is greater than 16 Amps the speed
14 is set using the algorithm in box 628. If the load is less
15 than 24 Amps, then the speed is increased from its last
16 value by 2 Hz until the saw load approaches 24 Hz. If the
17 load is greater than 24 Amps then control returns to box
18 643.
19   When the hardness is set to hard, if the saw motor load
20 is less than or equal to 16 Amps, then the VDF is set to 10
21 Hz box 646. As shown in box 647, if the saw load is greater
22 than 16 Amps, but less than 30 Amps, then the speed is set
23 using the algorithm in box 628. However, the speed is never
24 set less than 10 Hz box 648. If the saw load is less than
25 24 Amps then the speed in increased by 1Hz until the saw
26 load approaches 24 Amps. If the load is greater than 24
27 Amps, then control returns to box 628.
28   In FIG. 6a, there is no rock hardness selector function
29 and the VDF control logic in box 604a is the same as the
30 soft setting control logic box 647 FIG. 6f.
31   In an alternate embodiment of the present invention
32 shown in FIG. 6b there are five set speed setting of the
33 conveyor speed, box 604. If the saw motor load is less than

16 amps, the VFD is set to 30 Hz, box 622. If the saw motor
load is greater than 16 amps, but less than 20 amps, the VFD
is set to 22 Hz, box 623. If the saw motor load is greater
than 20 amps, but less than 23 amps, the VFD is set to 16
Hz, box 624. If the saw motor load is greater than 23 amps,
but less than 26 amps, the VFD is set to 9 Hz, box 625. If
the saw motor load is greater than 26 amps, but less than 30
amps, the VFD is set to 4 Hz, box 626. This embodiment
provides a piece wise approximation of the inverse transfer
function.

All of the examples of motor load and VDF and the exact
conversion algorithm are given using the values for the
currently preferred motors and drives and are given for
demonstrative purposes and are provide by way of example and
not of limitation. The values and algorithm could differ
for different equipment and different material to be cut.

FIG. 15 is a graph showing the relationship of saw
motor current (load) versus conveyor feed speed for hard and
soft materials for the embodiment shown in FIGS. 6e and 6f..
As shown in FIG. 6f, at conveyor start 621 the present
invention reads hard/soft setting box 640. When soft
material is selected the motor load is read by 504 (FIG. 5).
If the motor load is less than the sixteen Amps minimum
current 1516 decision box 643 sets the VFD speed to 30 Hz
line segment 1502.

When rock A contacts the blade 4, as seen in FIGS. 3
and 14, motor current increases as seen in segment 1501 and
conveyor variable speed drive is reduced by the slope of
1501 or -13/7 Amps/Hz. If the motor load is less than 24
Amps box 652, then the variable speed drive frequency is
given by equation 1550. If motor current is greater than
the minimum 16 Amps and less than nominal current, in this
case 24 Amps, then box 643 adds 2 Hz to the last speed

setting, increasing the system gain to the new line 1511. If the motor current is tested over 30 Amps (maximum) line 1530 and box 653 conveyors are stopped box 654.

If the motor current was less than 40-amps for 1.5 second or 30-amps for 10 seconds box 605 operation transfers to box 640. Operation resumes with calculating a new feed speed using equation 1550 in box 628. If current was greater than 40-amps for 1.5 second or 30-amps for 10 seconds then operation stops box 605 requiring a operator to clear the fault and restart the machine.

If speed calculation 1551 requests a speed increase, an additional 2-Hz offset is added for new transfer function 1552 line 1512. If new speed calculation 1551 requests no speed increase, the last speed is used. This continues until the nominal set current 1524 is exceeded in decision box 652 (FIG. 6f). A recalculation of a new feed speed is done using equation 1550. Algorithm 604 continuously servos feed speed maintain nominal cutting motor current thereby adapting to material size and or harness variations.

If the hard material is selected, line 642, operation is the same as taught for soft above except for the following changes: Low current maximum drive frequency/speed 1522 is 1/3 of 1502 (30 Hz) or 10 Hz. Adaptation offset frequency 1531 is 1 Hz. Hard material transfer function 1560 has a gain of -3/7 Amps/Hz and 118/7 and Hz offset.

The actual motor currents and feed speeds are offered by way of example and not limitation. Values are offered by way of example taught are a function of the specific machine capacity, gear-box ratios and types of materials being cut. Algorithm 604 may be replaced with a dedicated PID (proportional integral derivative) controller if higher performance is required. A controller such as the Gefran

model 2301 made by Gefran ISI Inc. of 8 Lowell Ave. Winchester, MA 01890 USA is offered by way of example. This way the system continuously servos to the nominal current thereby adapting to material size or hardness variations. Reduces stress on feed drive components, increases cutter life and smother operation. Fast acting over current fault protection increases machine safety. The fast acting servo taught above automatically reduces feed rates, reducing the chances for a catastrophic fault. A two material selector is offered by way of example and not limitation. The simple two material switch may be replaced with continuous controls for nominal current set point 1524, minimum current 1516 , maximum speed 1522 and offset 1531 parameters.

Although the present invention has been described with reference to preferred embodiments, numerous modifications and variations can be made and still the result will come within the scope of the invention. No limitation with respect to the specific embodiments disclosed herein is intended or should be inferred. Each apparatus embodiment described herein has numerous equivalents.